

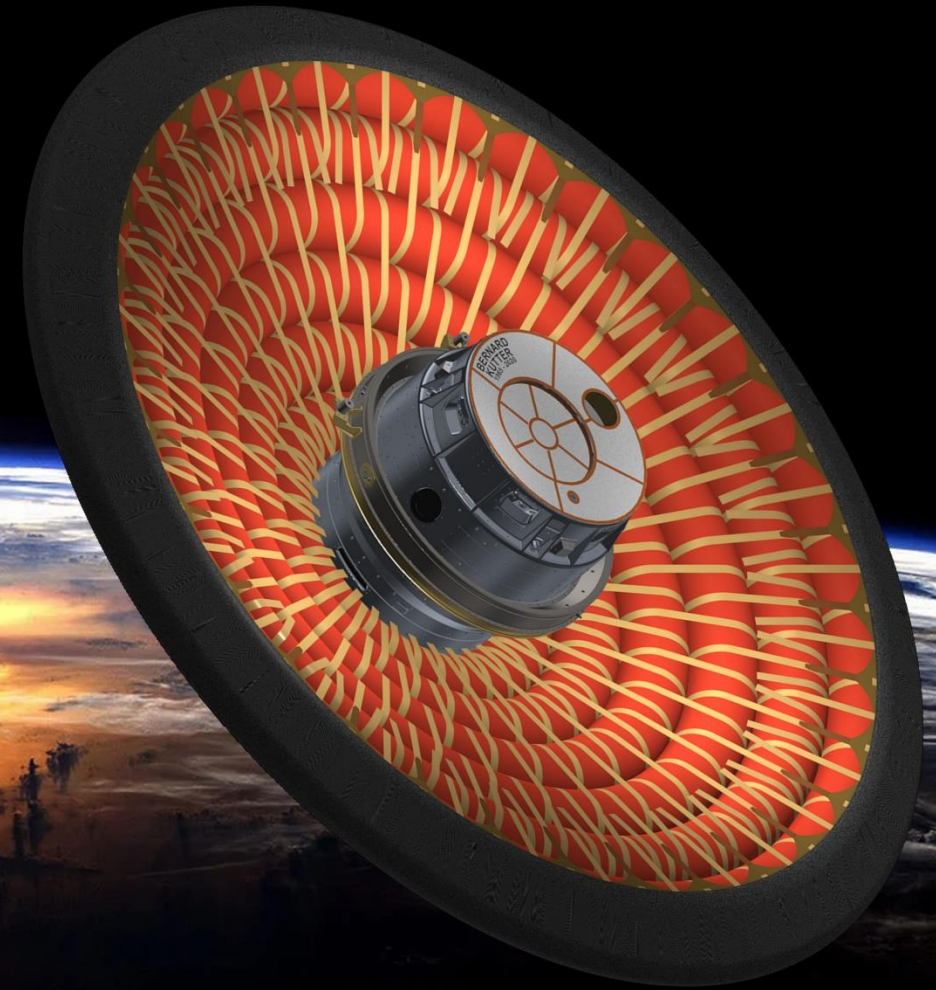


Low-Earth Orbit Flight Test
of an Inflatable Decelerator

National Aeronautics and
Space Administration



Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) Aeroshell Performance



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NASA Ames Research Center

AIAA SciTech Forum
8-12 January 2024

Deployment – Centaur Camera



Packing Restraint Release



Aeroshell Inflation



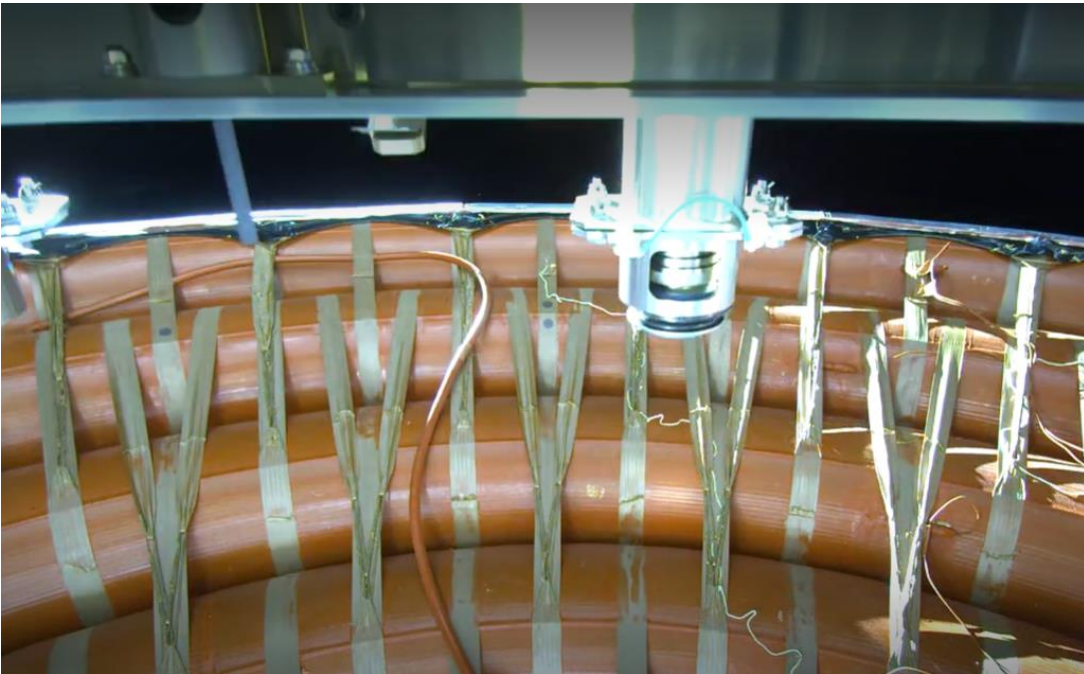
Self Deployment from Stored Energy



Separation Over Sinai Peninsula

Separation – On Board Cameras

Aft Segment Camera Pod



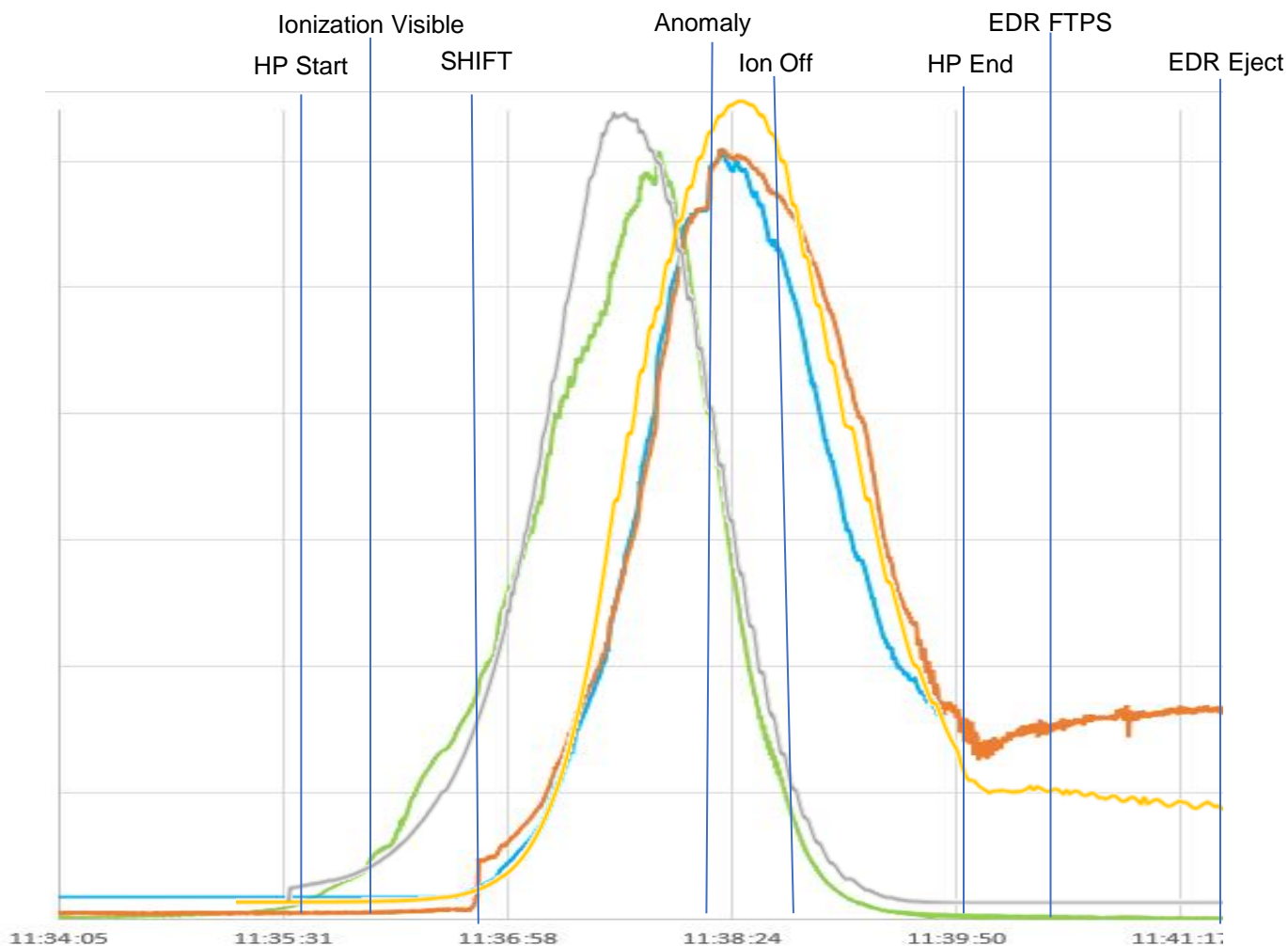
Uplook Camera





IDR ADAU HFG/LCP/Nose PT vs Pre-Flight Prediction

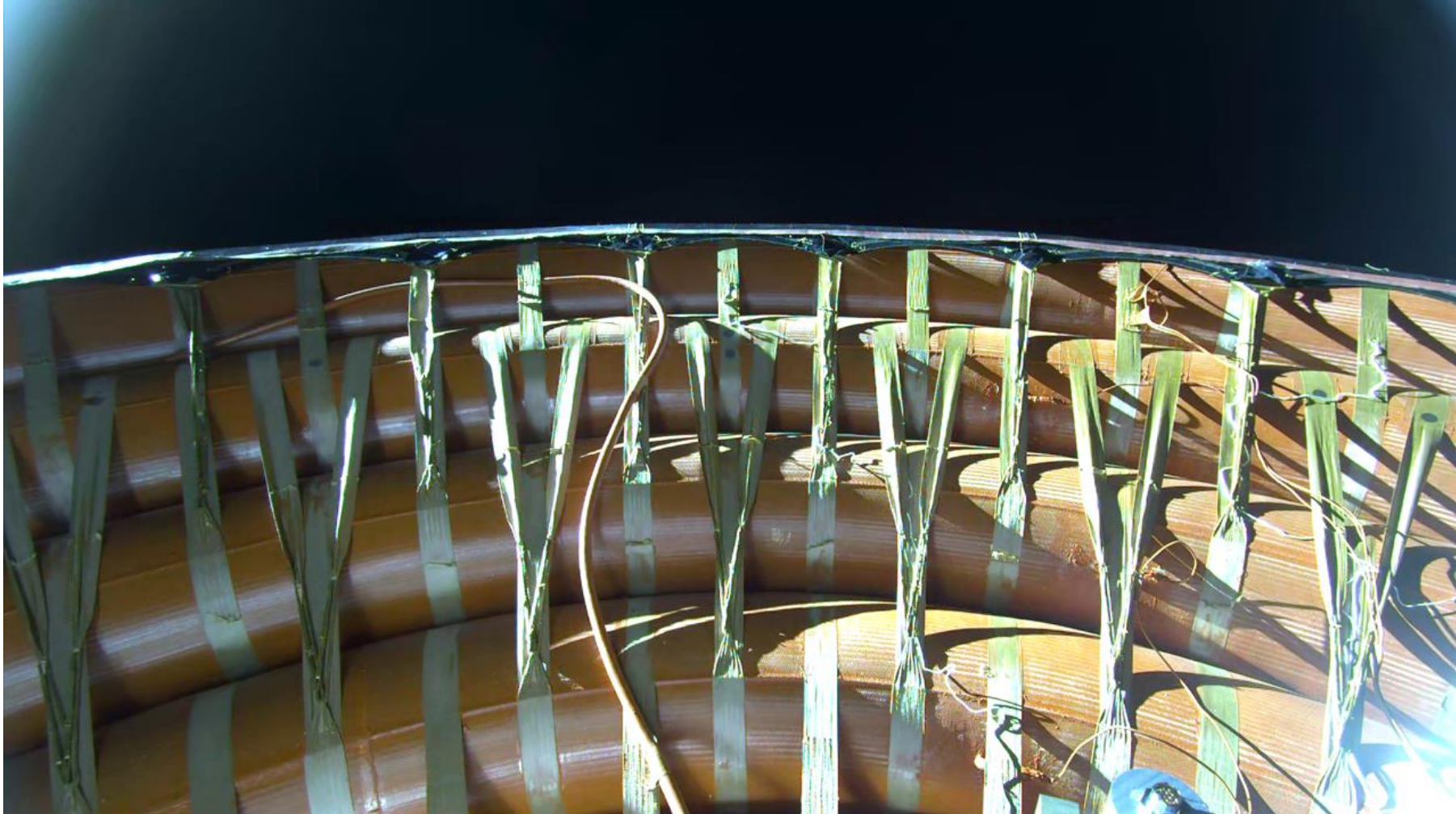
POST Pressure Pulse (prediction)
POST Heat Pulse (prediction)
Flight Heat Flux Gage (HFG)
Flight Strap Load Cell (LCP)
Surface Pressure Transducer (PT)



Note: The amplitude of the actual flight data was stretched to approximate the same magnitude of the pre-flight middle window prediction showing the shape/timing of events was generally in line with the POST simulation



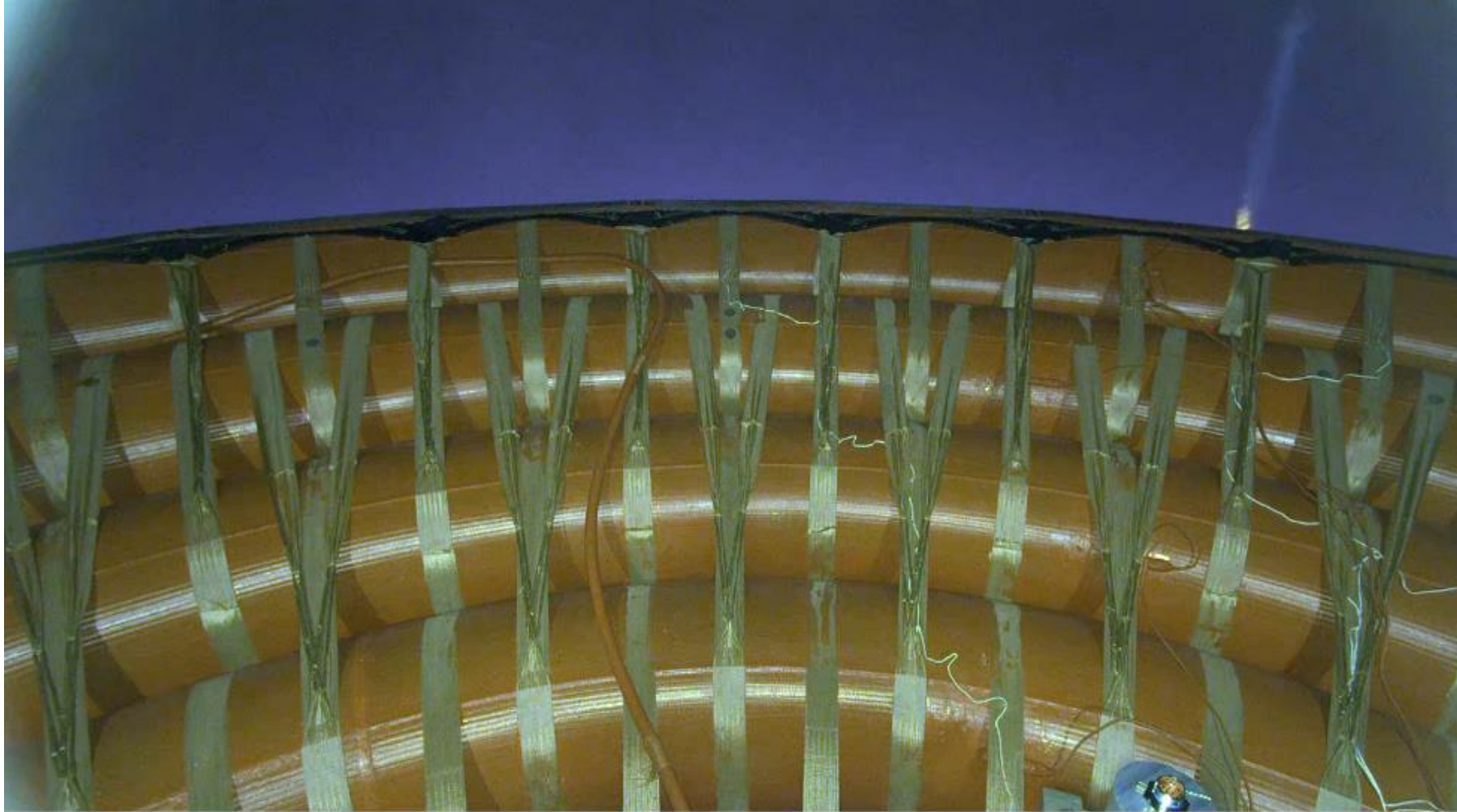
Camera Pod 1 (CP1) Visible Light Camera - Coast Phase



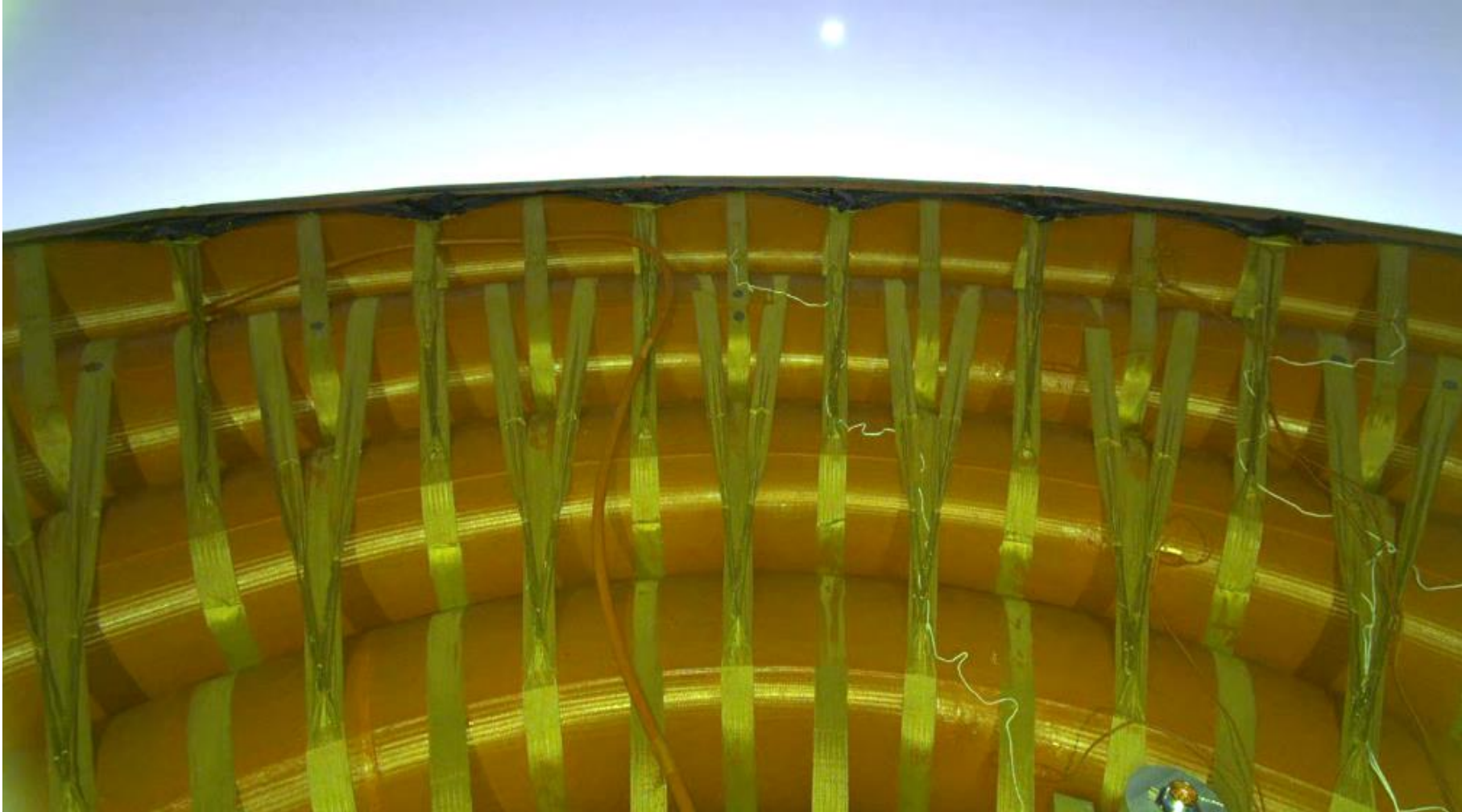
CP1 Begin to See Ionizing Flow



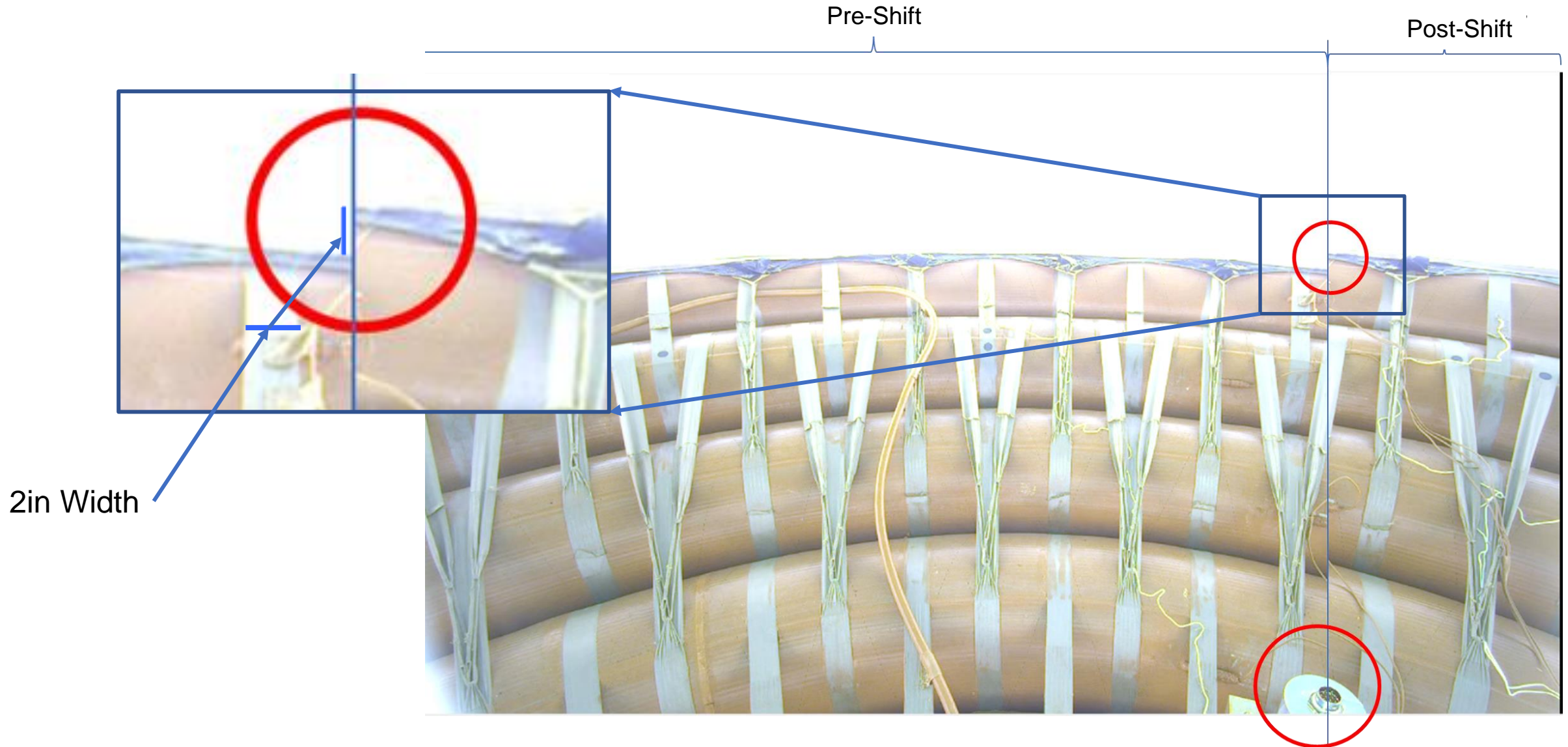
CP1 Payload Adaptor Burning Up



CP1 Ionizing Flow Very Evident



CP1 Aeroshell Aft Shift





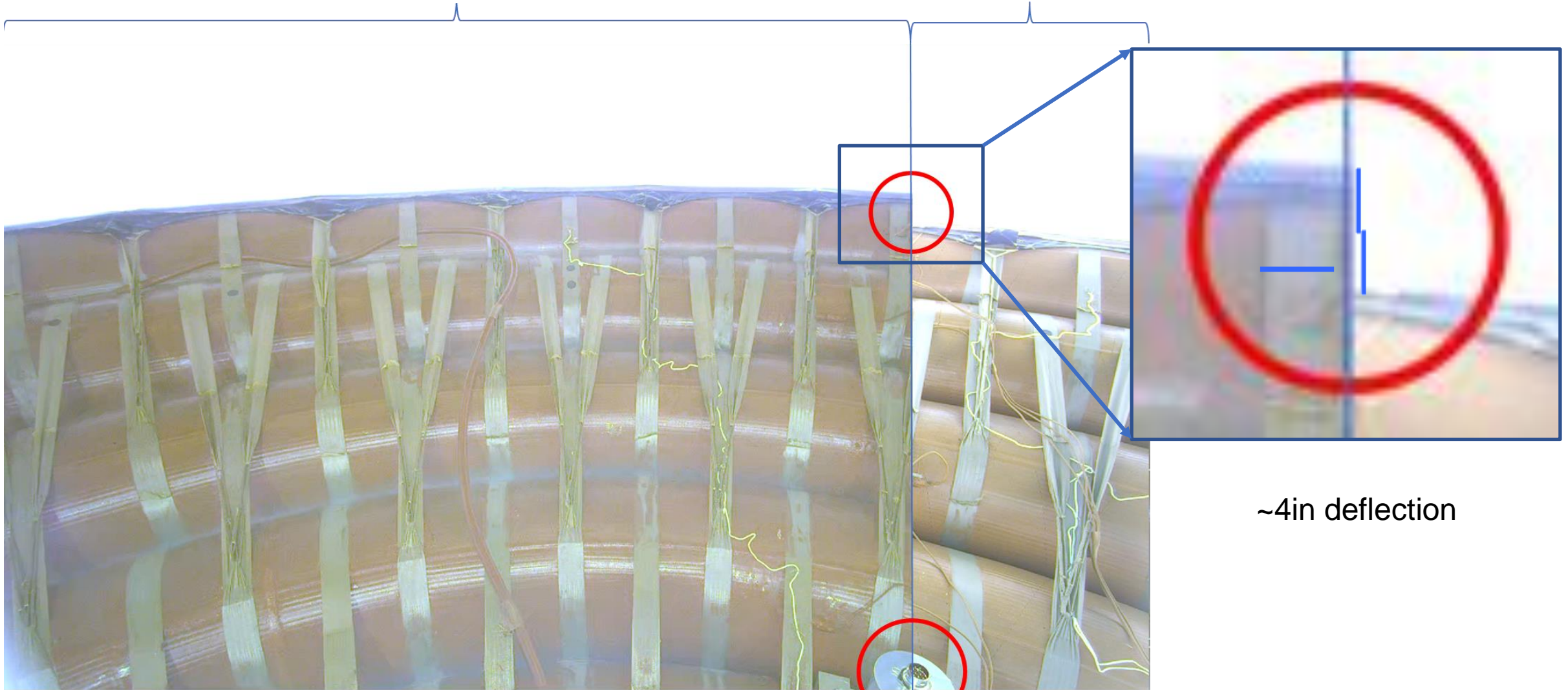
CP1 Peak Heating



CP1 Peak Dynamic Pressure vs Beginning Pressure Pulse

Peak Dynamic Pressure

Beginning Pressure Pulse



~4in deflection



Deflection Angle Calculation Example

Measured distances between camera and dot (from CAD):

X: 62.7393 in = 1.5936 m

Y: 8.4395 in = 0.2144 m

Z: 20.2198 in = 0.5136 m

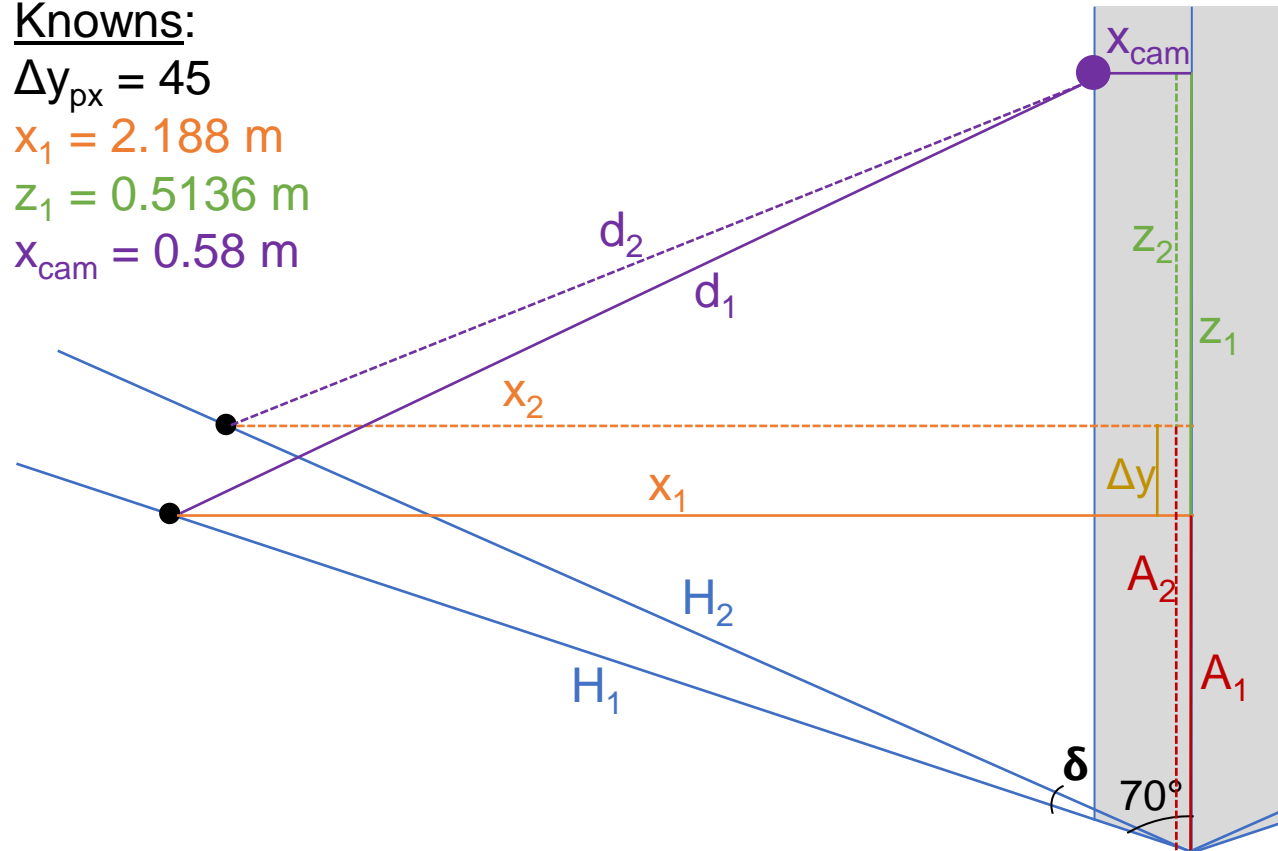
Knowns:

$\Delta y_{px} = 45$

$x_1 = 2.188 \text{ m}$

$z_1 = 0.5136 \text{ m}$

$x_{cam} = 0.58 \text{ m}$



$$\text{Resolution (y-direction)} = \frac{56.7^\circ}{1080 \text{ px}} = 0.0525^\circ/\text{px}$$

$$d_1 = \sqrt{(x_1 - x_{cam})^2 + z_1^2} = 1.688 \text{ m}$$

$$s_1 = 1.688 \tan(0.0525^\circ) \approx s_2 = 0.0015 \text{ m/px}$$

$$\Delta y = 25 \text{ px} \times 0.0015 \frac{\text{m}}{\text{px}} = 0.03867 \text{ m}$$

$$z_2 = 0.5136 - 0.03867 = 0.4749 \text{ m}$$

$$A_1 = \frac{2.188}{\tan 70^\circ} = 0.7964 \text{ m}$$

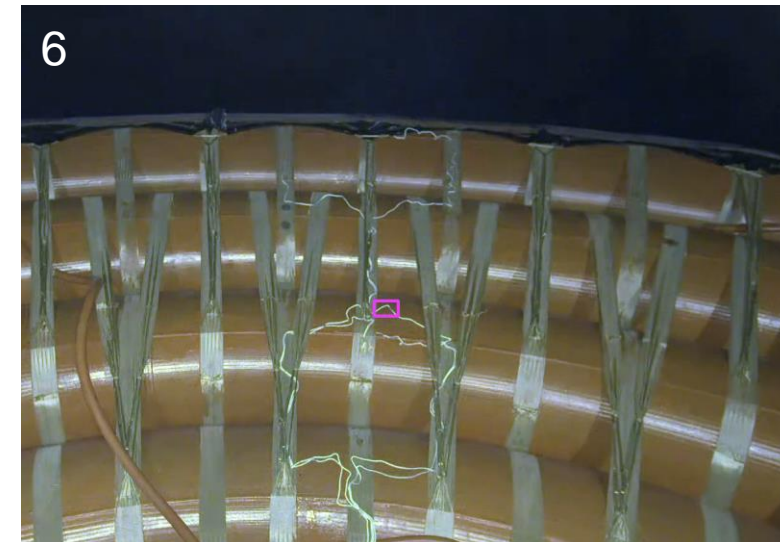
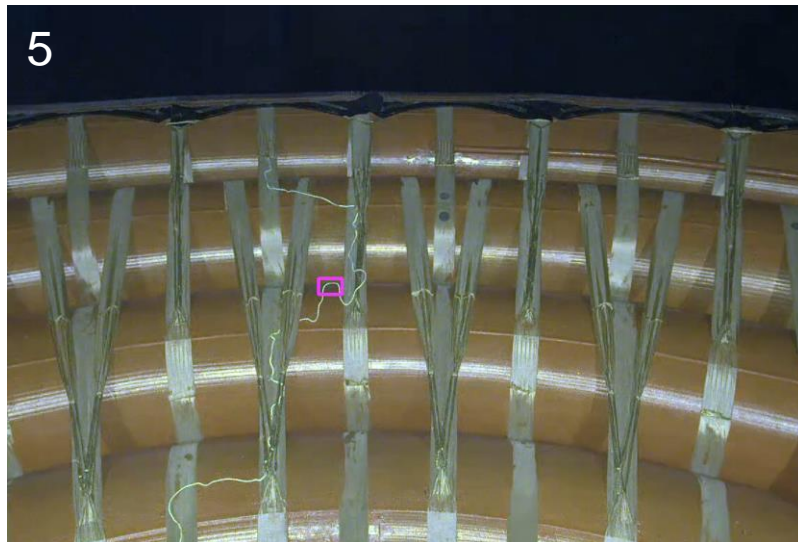
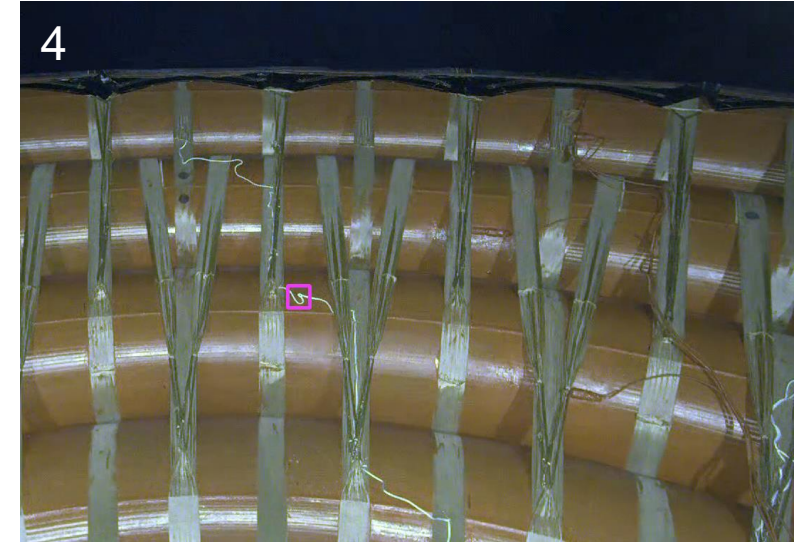
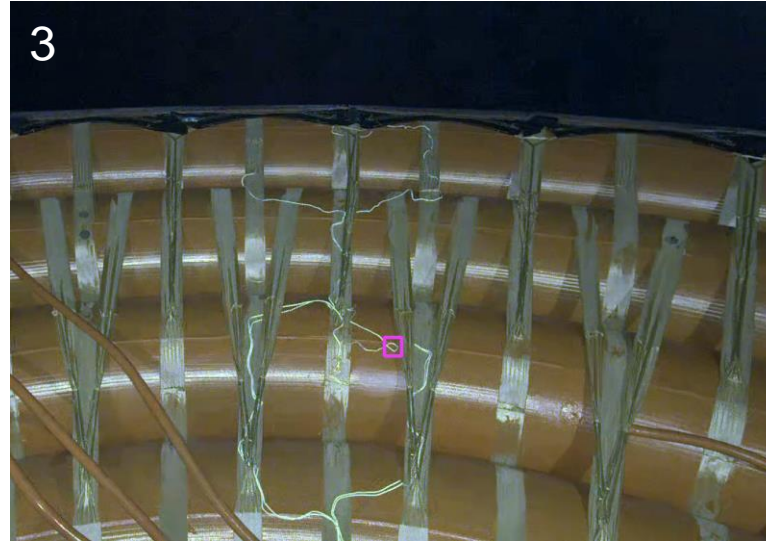
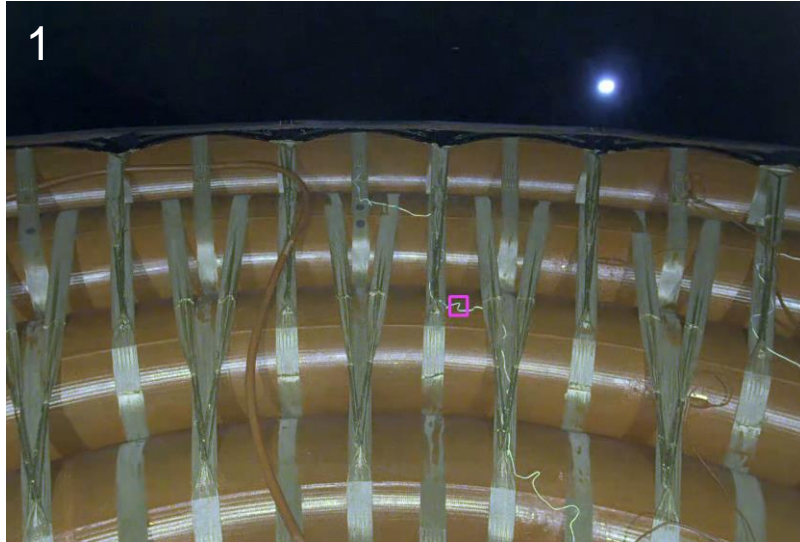
$$H_1 = \frac{2.188}{\sin 70^\circ} = 2.3283 \text{ m}$$

$$A_2 = 0.7963 + 0.5136 - 0.4749 = 0.8351 \text{ m}$$

$$\delta = 70^\circ - \cos^{-1}\left(\frac{0.8351}{2.3283}\right) = 1.02^\circ$$

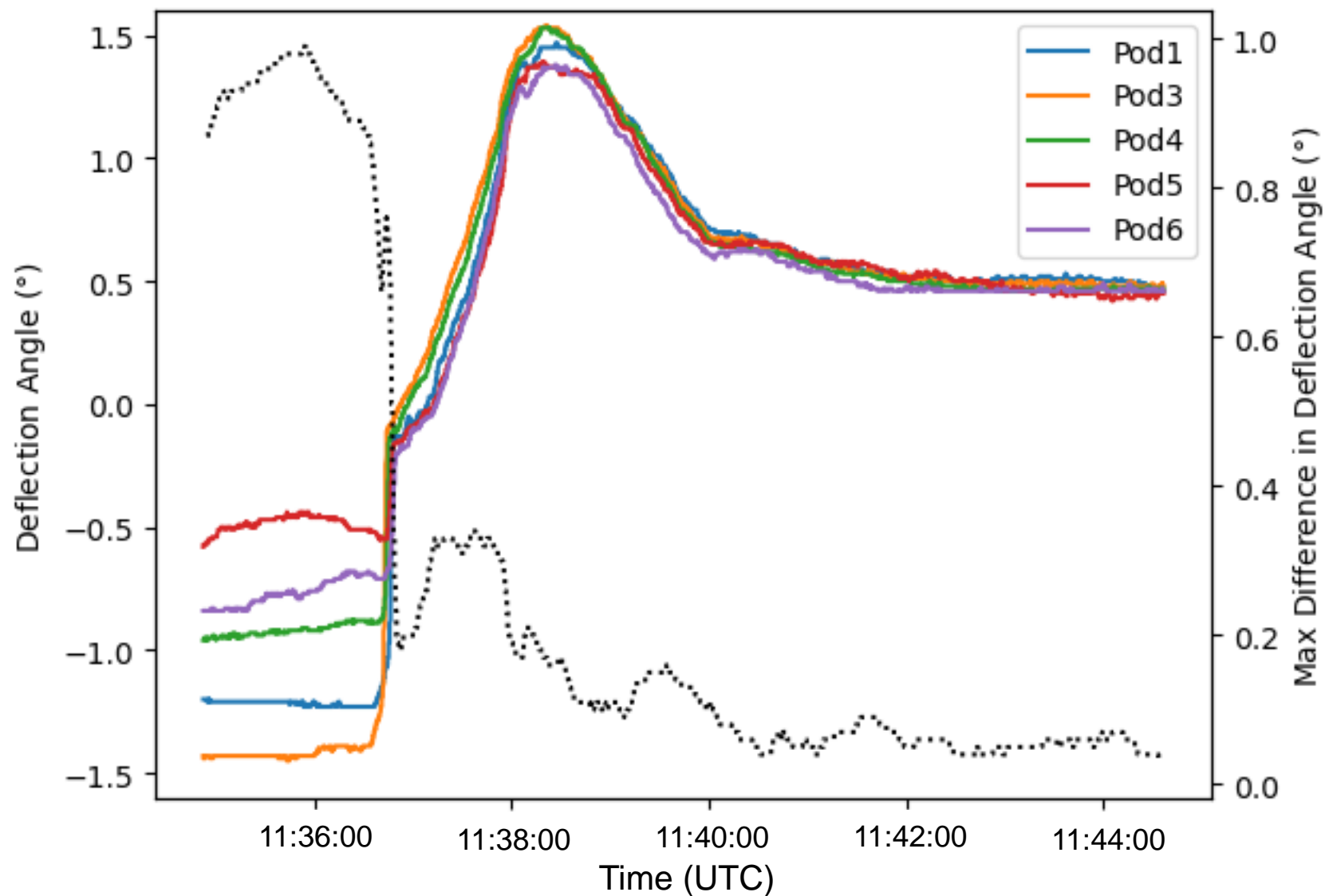
Initial Investigation Credit: Hanna Alpert

Tracked Features in Flight



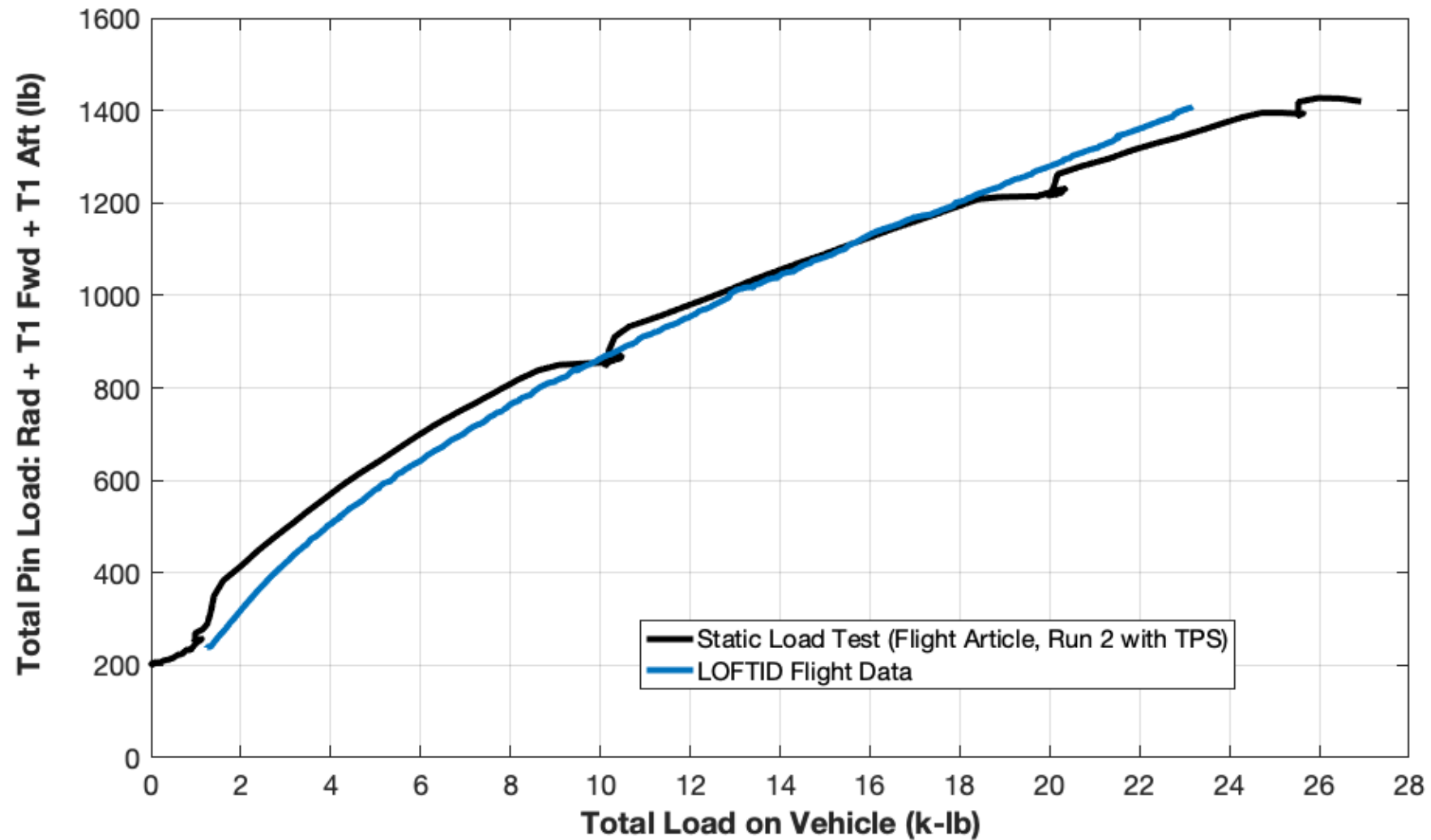
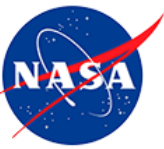


Difference in Deflection Angle Across Aeroshell

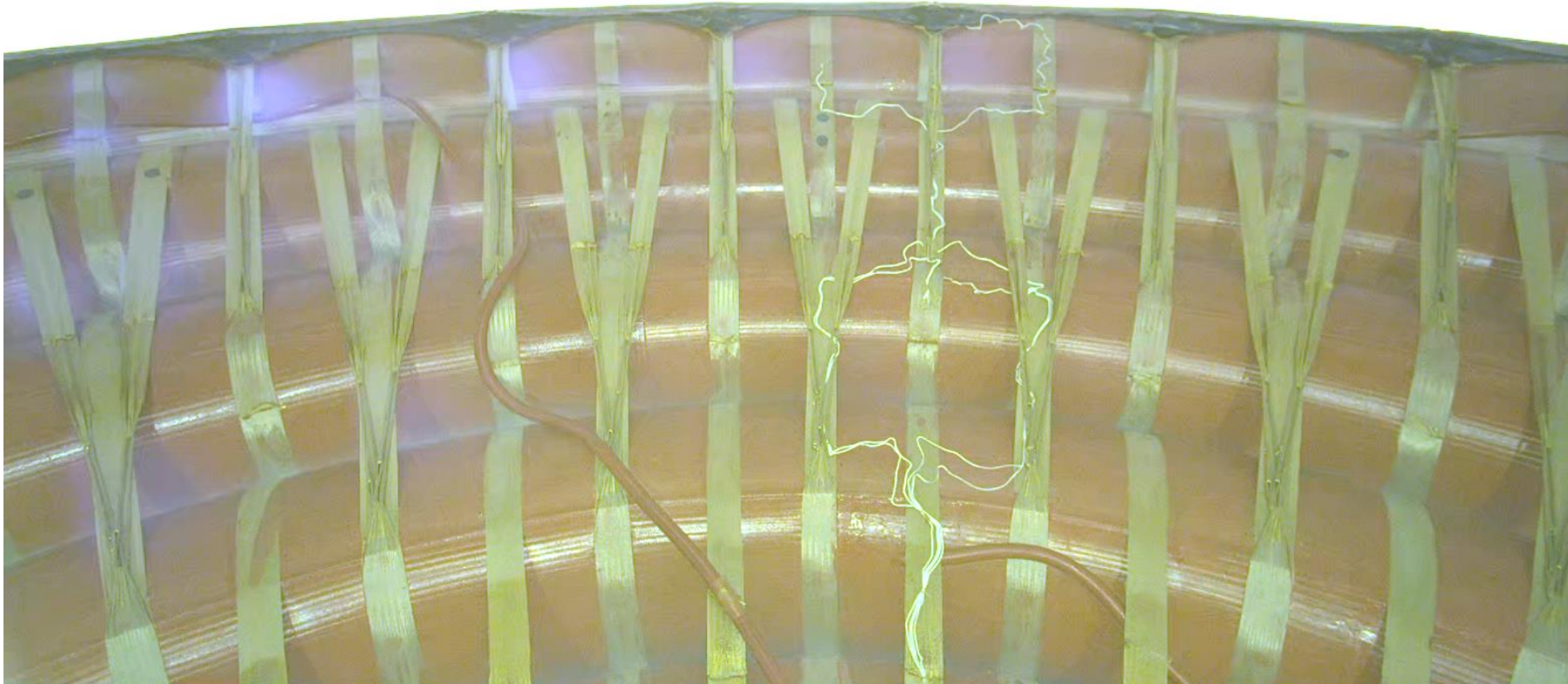


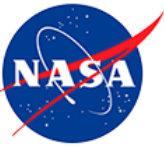


Flight Load Cell Pin Measurements Correlated to Pre-Flight Testing

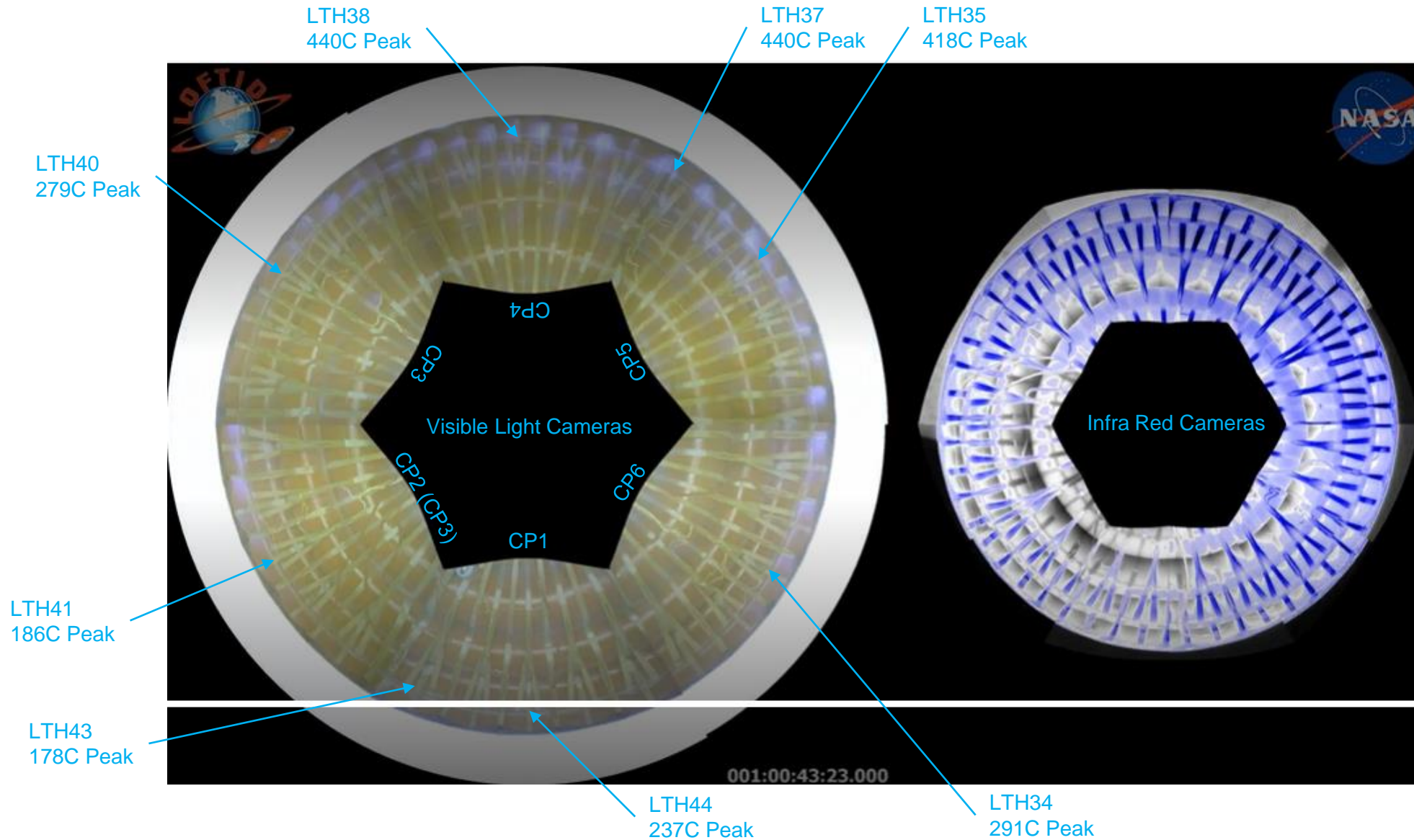


CP1 Ionizing Flow in the Valley Between T5 & T6



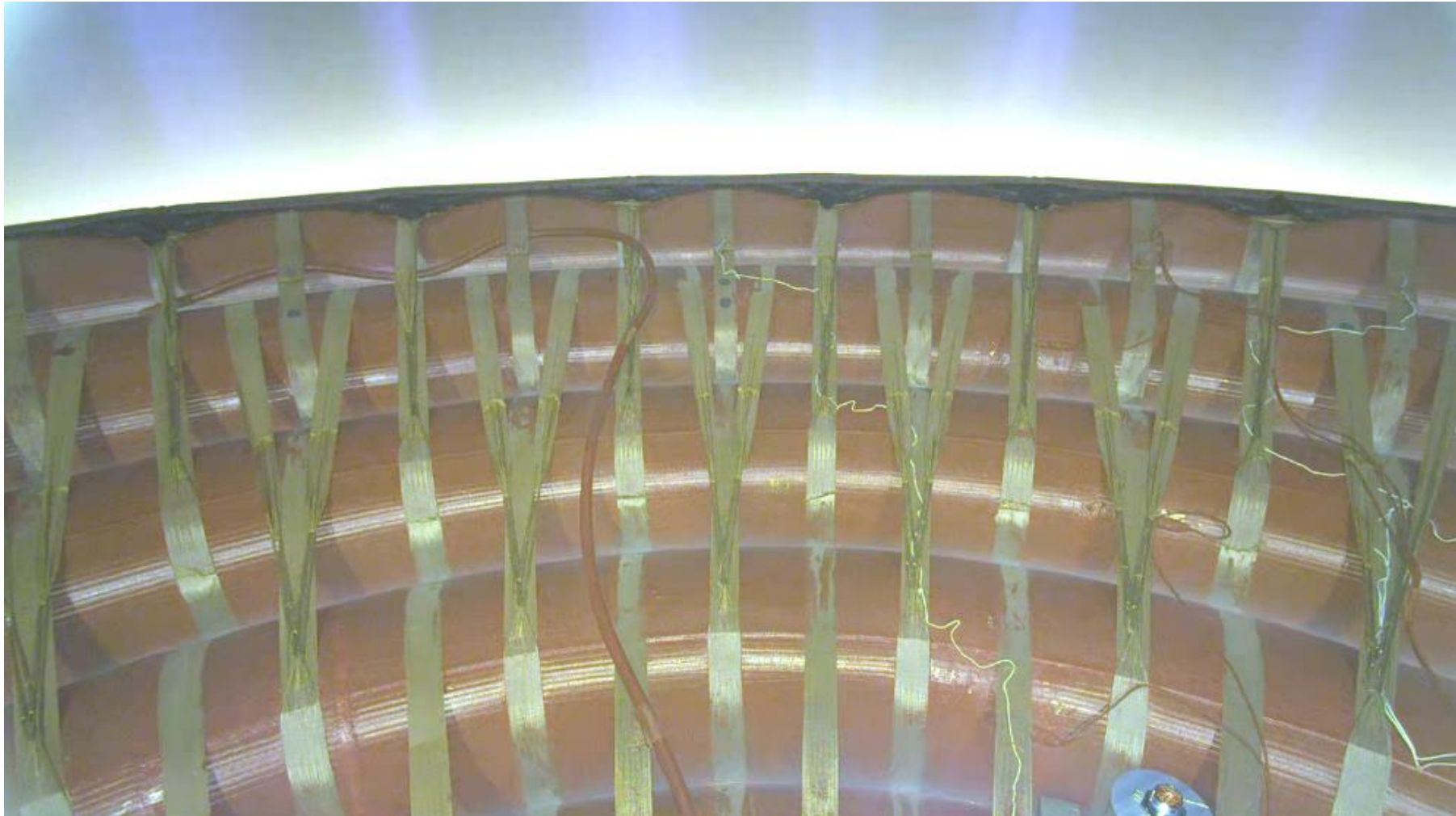


Aft Webbing Temperature and Plasma Locations



Note: CP2 Visible Light Camera failed and is a duplicate of CP3 in the composite

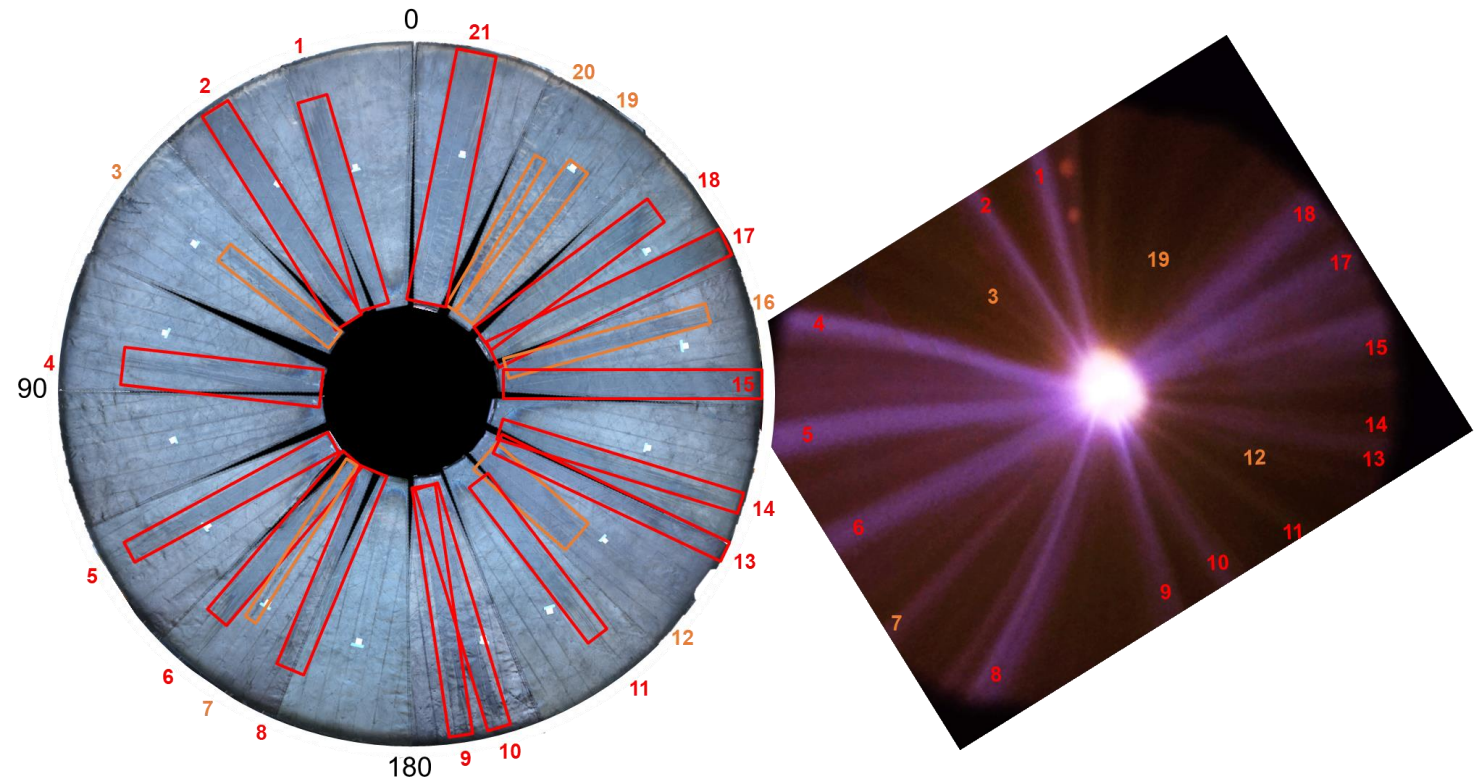
CP1 Ionizing Flow Diminishing



Flow Ionization and FWD Surface Streaking

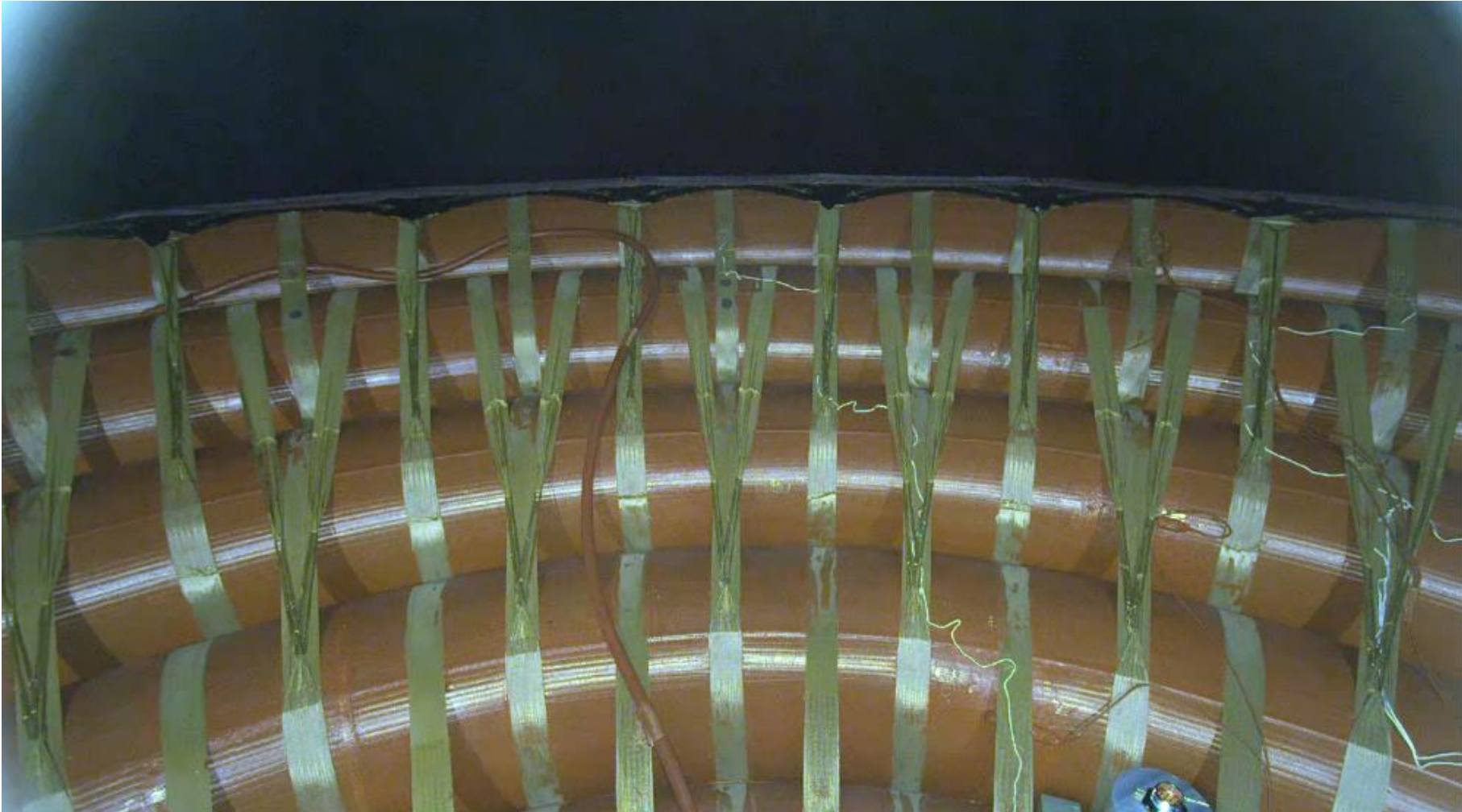


Early in the pulse prior to peak heating (~25% peak heating) hot gas streaks appear as 16 equally distributed rays that appear to line up with outer fabric gore seams



Later in the pulse well past peak pressure many more rays are present, not equally spaced, possibly lined up with the streaks on the forward Aeroshell surface

CP1 Ionizing Flow Appears to be Finished





IR Image Reentry Vehicle Descending Under Chute





Reentry Vehicle Floating Behind Recovery Vessel



Reentry Vehicle First Contact

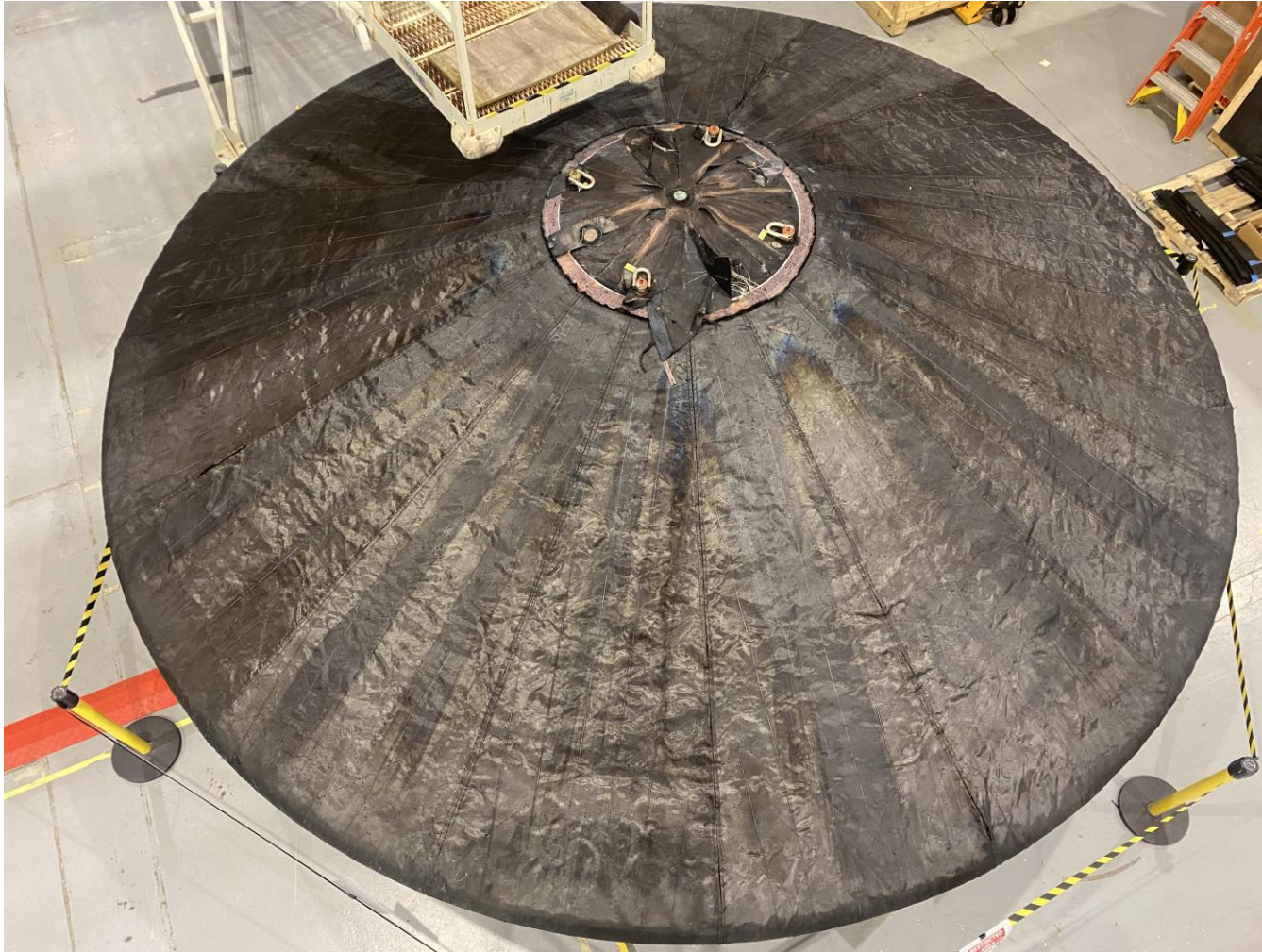




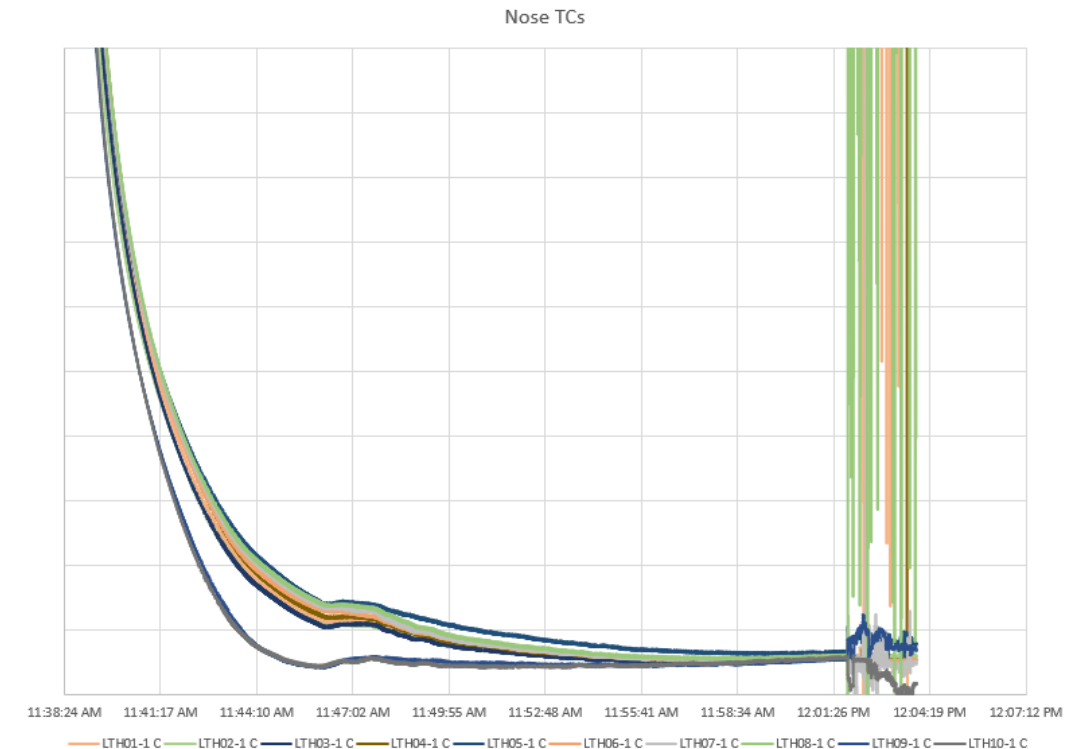
Reentry Vehicle on the Deck of the Recovery Vessel

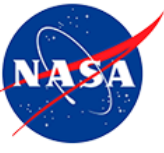


Post Flight Aeroshell



Note: The nose FTPS was lost some time between water impact and lifting out of the water. The plot in the lower right is the plot of nose TCs during descent. The bump up aligns with the deployment of the pilot and main chute. The insulators which are warmer at this point recontact the outer fabric and bump up the temperature. TC plots look fine after the bump until water impact.

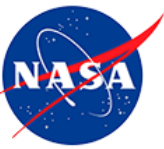




Back-up

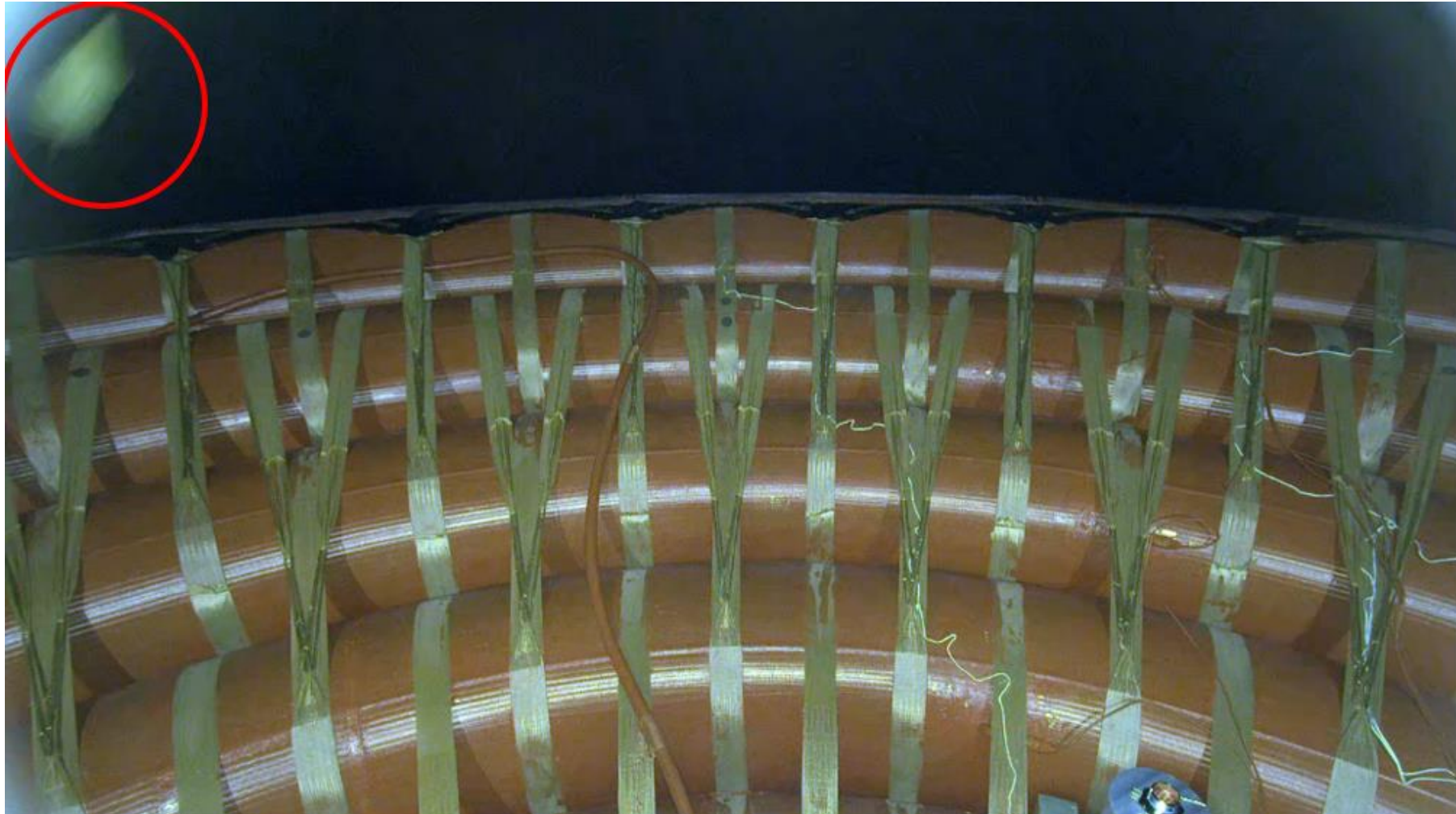
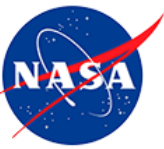


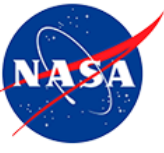
CP1 Ejectable Data Recorder FTPS Prematurely Separating





CP1 Ejectable Data Recorder Ejection





CP1 Pilot Mortar Fire



CP1 Debris From Mortar Fire

